PB88-180021

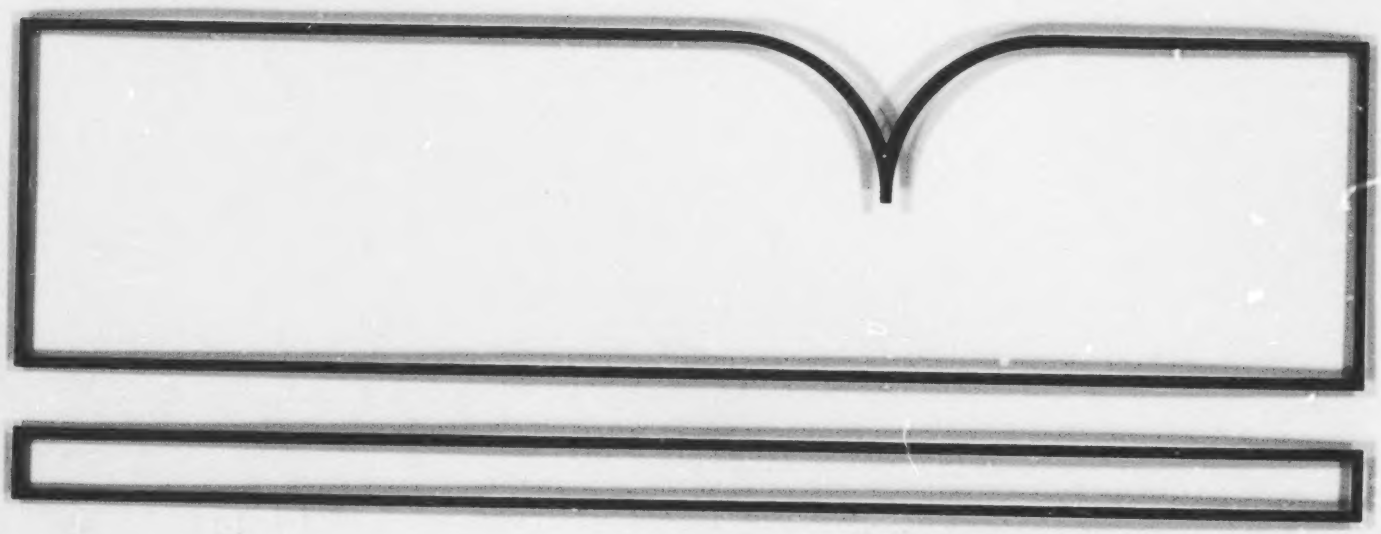
Air Quality Modeling Analysis of Industrial Point Sources in Everett, Washington

TRC Environmental Consultants, Inc.
Mountainlake Terrace, WA

Prepared for

Environmental Protection Agency, Seattle, WA

2 Mar 88



U.S. Department of Commerce
National Technical Information Service
NTIS

REPORT DOCUMENTATION PAGE	1. REPORT NO. EPA 910/9-87-175	2.	3. PB88-180021

4. Title and Subtitle
AIR QUALITY MODELING ANALYSIS OF INDUSTRIAL POINT SOURCES IN EVERETT, WASHINGTON

5. Report Date
MARCH 2, 1988

6.

7. Author(s)
E.B. HANSEN AND K.D. WINGES

8. Performing Organization Rept. No.
EPA 910/9-87-175

9. Performing Organization Name and Address
TRC ENVIRONMENTAL CONSULTANTS, INC.
21907 64th AVENUE WEST, SUITE 230
MOUNTLAKE TERRACE, WASHINGTON 98043

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C) 68-02-3886, WA 59
(G)

12. Sponsoring Organization Name and Address
U.S. ENVIRONMENTAL PROTECTION AGENCY, REGION 10
1200 SIXTH AVENUE
SEATTLE, WASHINGTON 98101

13. Type of Report & Period Covered
FINAL REPORT
6/87-3/88

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)
The maximum allowable emissions from operating permits for Scott Paper Company and Weyerhaeuser Company pulp and paper mills in Everett, Washington were obtained from Washington Department of Ecology. A 5-year sequential meteorological data base was prepared using wind data from the Puget Sound Air Pollution Control Agency monitoring station in Everett, surface observations from Sea-Tac Airport, and upper air data from Quillayute, Washington. The mill's emissions of sulfur dioxide and particulate matter were modeled using the most recent versions of COMPLEX1, SHORTZ, and ISCST to determine 1) if the existing monitoring site was located such that maximum concentrations are measured; and 2) if existing permit limits on emissions were sufficient to ensure compliance with State and Federal ambient air quality standards.

17. Document Analysis a. Descriptors
Air pollution
Mathematical models
Computer models

b. Identifiers/Open-Ended Terms
Industrial sources
Dispersion

c. COSATI Field/Group

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL
INFORMATION SERVICE
SPRINGFIELD, VA. 22161

18. Availability Statement

19. Security Class (This Report) Unclassified

20. Security Class (This Page) Unclassified

21. No. of Pages 43

22. Price A03 12.95

EPA-910/9-87-175

AIR QUALITY MODELING ANALYSIS OF INDUSTRIAL POINT SOURCES IN EVERETT, WASHINGTON

PREPARED FOR

MR. ROBERT WILSON
U.S. ENVIRONMENTAL PROTECTION AGENCY
SEATTLE, WASHINGTON

MARCH, 1988

TRC
Environmental Consultants

21907 64th Avenue, W.
Suite 230
Mountlake Terrace, WA 98043

(206) 778-5003

A TRC Company

AIR QUALITY MODELING ANALYSIS OF INDUSTRIAL POINT SOURCES IN EVERETT, WASHINGTON

INTRODUCTION

TRC Environmental Consultants was retained by the Region 10 office of the U.S. Environmental Protection Agency to conduct an air quality dispersion modeling study of industrial point sources in Everett, Washington. The purposes of the modeling study were 1) to check the adequacy of commitments in the State Implementation Plan which were designed to maintain compliance with ambient standards, and 2) to determine whether the air quality monitoring station in Everett is in a suitable location.

Maximum allowable emissions from the Scott Paper Company and Weyerhaeuser Company pulp and paper mills were obtained from Washington Department of Ecology. These emissions were evaluated using EPA models and meteorological records from a nearby air quality monitoring station, Sea-Tac Airport, and the Washington upper-air monitoring station at Quillayute Airport.

MODELS USED

TRC was directed to use three dispersion models from the UNAMAP Version 6 model series: ISCST (Version 86322), COMPLEX-1 (Version 86064), and SHORTZ (Version 82326). In each case, the model is the latest available version of the model.

The Guideline on Air Quality Models (Environmental Protection Agency, 1986a) states that the Industrial Source Complex (Environmental Protection Agency, 1986b) model is appropriate for use in rural or urban areas with flat or rolling terrain. It is not intended to be used to estimate concentrations at locations which are higher than the stack being modeled. ISC can account for building downwash and for settling and dry deposition of particulate matter. ISC assumes that plume elevation is unaffected by terrain, so that as the plume passes over terrain higher than the stack base elevation, the distance between the plume centerline and a receptor is reduced. However, if terrain elevations greater than any stack height are entered into ISC, the receptor elevation is automatically set to 0.005 meters below stack height when the ISC model computes the contribution from that stack. It should be noted that this height may be much lower than the plume centerline height because of plume rise.

COMPLEX-1 is the recommended second-level screening model for rural areas with complex terrain. Complex terrain is defined as an area where terrain exceeds the height of the stack being modeled. COMPLEX-1 uses the same plume impaction algorithm that EPA's VALLEY model (Burt, 1977) uses, wherein the plume centerline is not allowed to come within 10 meters of elevated terrain.

The Guidelines specify the use of SHORTZ (Bjorklund and Bowers, 1982) in urban areas with complex terrain. Despite the presence of buildings and substantial

population, the area is classified as rural because of the large fraction of the surrounding area which is rural or covered by water. Although not intended for rural areas, SHORTZ was used in this evaluation because it has been used historically in the Puget Sound area.

SHORTZ can account for settling and dry deposition of particulate matter. The primary difference between SHORTZ and ISC is the treatment of terrain effects: ISC will not allow receptors with heights greater than the stack height, while SHORTZ will. SHORTZ allows the plume to directly "impact" the terrain, such that receptor can be placed right at the plume centerline. For any terrain height equal to or greater than the plume centerline height, the vertical separation between plume centerline and receptor is assumed to be zero. Another significant difference between SHORTZ and ISC is in the treatment of downwash. Both models have the capability to treat "stack-tip" downwash, but only ISC evaluates the effects of building wakes on plume heights. In accordance with the SHORTZ users guide, Froude numbers were evaluated for each source and stack radii were adjusted as necessary.

DATA SOURCES

TRC obtained hourly wind speed and direction data for the period from 1982 through 1986, inclusive, from an air quality monitoring station maintained by the Puget Sound Air Pollution Control Agency (PSAPCA) in Everett. The station is located at 2730 Colby Avenue, on the roof of the Medical Dental Building. Wind data are collected by instruments located 118 feet above the ground, which is 125 feet above mean sea level. Thus, the wind sensors are located a total of 243 feet above mean sea level.

The development of a suitable meteorological data base for the modeling required TRC to incorporate Everett wind data with other meteorological data from Sea-Tac Airport and the airport at Quillayute, Washington.

The first step in creating the 1982-1986 meteorological data set was to run the RAMMET preprocessor (Turner and Novak, 1978) for the 5 years using surface meteorological data collected at Sea-Tac and upper air data from Quillayute. Seattle climatological values (Holzworth, 1972) were substituted for missing mixing height values.

The second step was to create a meteorological data base using Everett wind speed and direction data with the concurrent Sea-Tac ceiling heights, cloud cover and temperature, and the Quillayute upper air data. During the creation of this data base, Everett wind speeds were scaled down from the 118 foot sensor height to a height of 10 meters using the airport stabilities determined in step 1 and the stability-dependent exponential scaling formula used in the RAMMET preprocessor. Airport wind speed and direction data were substituted where Everett data were missing. This data base was then input to the RAMMET preprocessor to create a sequential meteorological data base.

A wind rose plotted with the 1982 wind data produced by this process is presented in Figure 1. It differs slightly from the wind rose for the Medical

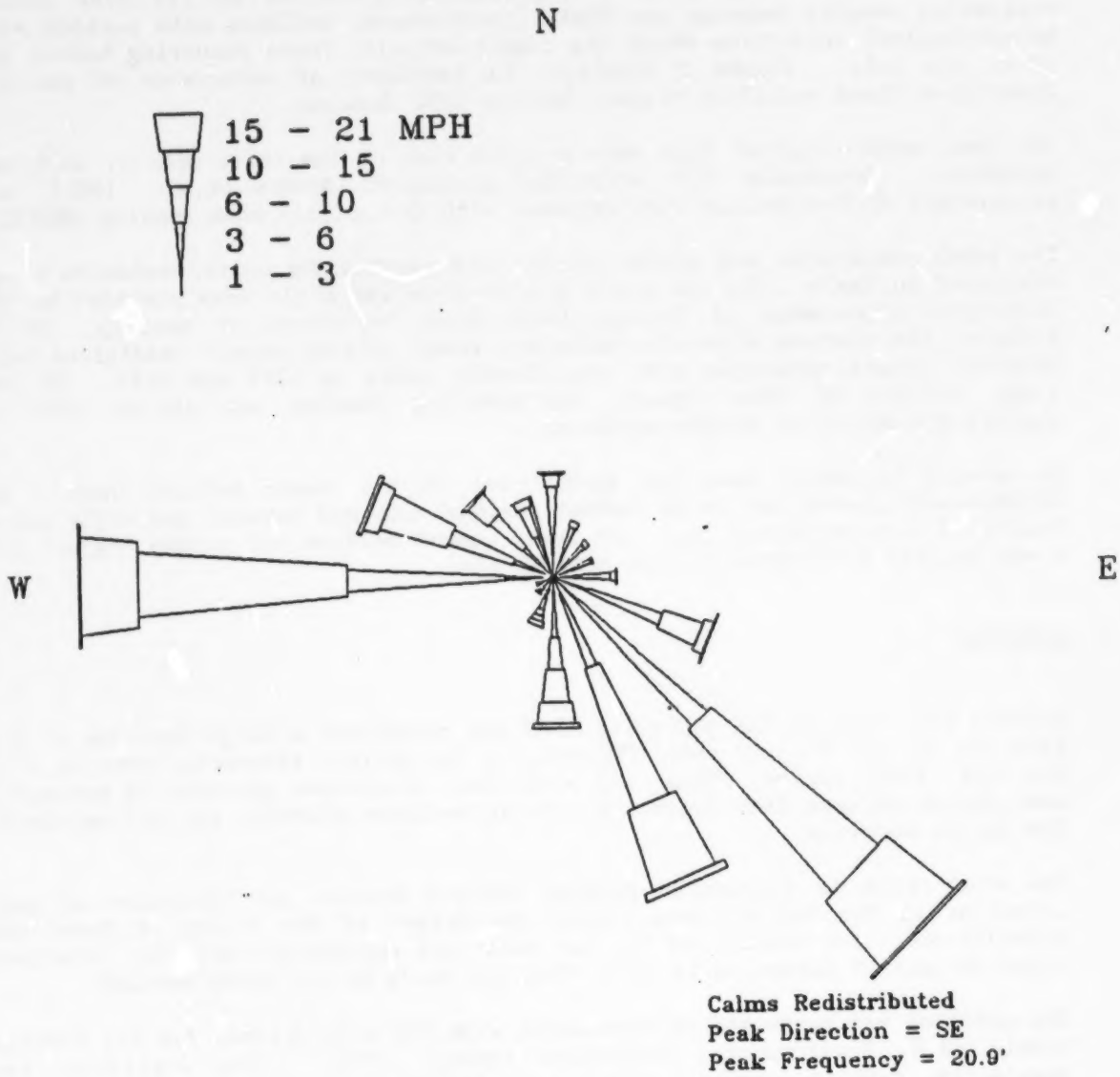


FIGURE 1: 1982 WIND ROSE FROM THE MEDICAL-DENTAL BUILDING IN EVERETT

Dental Building monitoring station published by PSAPCA in its 1982 annual monitoring summary because the RAMMET preprocessor replaces calm periods with meteorological conditions which are consistent with those occurring before and after the calm. Figure 2 displays the frequency of occurrence of the six Pasquill-Gifford stability classes for the 1982 data set.

The same meteorological data were used in each of the three models, with one exception. Consistent with historical precedent (Bowers et.al., 1982), all occurrences of F-stability were replaced with E-stability when running SHORTZ.

The stack parameters and sulfur dioxide and particulate matter emission rates displayed in Table 1 for the Scott and Weyerhaeuser mills were provided by the Washington Department of Ecology (Washington Department of Ecology, 1987). Although the maximum allowable emissions under current permit conditions were modeled, actual emissions were considerably lower in 1985 and 1986. In the final section of this report, the modeling results are scaled down to approximate actual operating conditions.

It should be noted that the fuels used in the power boilers vary. At Weyerhaeuser, power boiler #1 burned residual oil and natural gas while power boiler #2 burned natural gas. At Scott, power boilers 1-5 burned hogfuel but power boilers 6-9 burned oil and natural gas.

APPROACH

Because Port Gardner Bay and rural land use constitute a large fraction of the land use in the Everett area, TRC modeled the Everett industrial sources with the rural model option. Thus, any additional dispersion provided by potential heat island effects from Everett's central business district was not accounted for in the modeling.

The study area is considered complex terrain because the elevation of many locations in the Everett area exceed the height of the stacks at Scott and Weyerhaeuser. The results of the ISC model are appropriate only for locations where the ground elevation is lower than the stack height being modeled.

The modeling was performed in accordance with EPA's Guidelines for Air Quality Models (U.S. Environmental Protection Agency, 1986). When available, the regulatory default options were used for each model. These included consideration of stack downwash, buoyancy induced dispersion, and default vertical potential temperature gradients and wind profile exponents. EPA's method of adjusting for calm periods was used in all cases.

TRC's modeling study began with a grid of receptors, spaced 1-kilometer apart, bounded by UTM coordinates 556-561, and 5310-5325. In terms of local geography, this grid ranged from the Everett Golf and Country Club on the south to north of Marysville, and from just west of the Everett jetty to the Snohomish River east of Everett. Ground elevations were entered in the models based on USGS maps of the area. A contour map based on elevations entered at

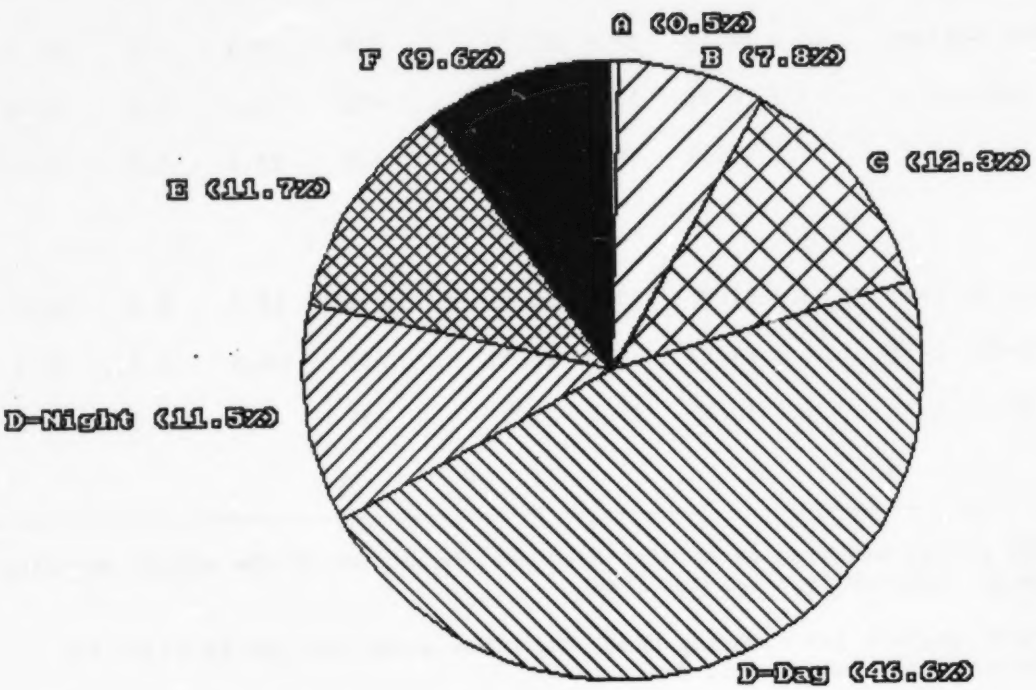


FIGURE 2: FREQUENCY OF OCCURRENCE OF STABILITY CLASSES IN 1982

TABLE 1: SUMMARY OF WEYERHAEUSER AND SCOTT EMISSION SOURCES

Source	EMISSIONS Permitted (Actual)[1] (grams/second) PM-10	SO2	TEMP. (°K)	EXIT SPEED (m/sec)	STACK DIAM. (m)	STACK HEIGHT (m)
Weyerhaeuser:						
Recovery Boiler	10.6 (8.1)	59.9 (17.3)	339	10.3	3.7	85.3
Power Boil. # 1	3.2 (0.8)	36.6 (11.5)	422	11.5	1.5	36.6
Power Boil. # 2	6.1 (0.4)	69.3 (4.2)	455	23.4	1.5	36.0
Scott:						
Recovery Boiler	6.2 (1.0)	35.1 (15.7)	299	18.5	1.8	61.6
Power Boil. 1-5[2]	4.1 (4.1)	46.1 (0.1)	455	4.5	4.1	50.3
Power Boil. 6-9	2.6 (0.3)	29.5 (3.8)	422	6.2	1.8	31.1

1 The actual emission rates displayed are the higher of the actual emission rates reported for 1985 and 1986.

2 Power boilers 1-5 burn hog fuel; the other power boilers at Scott and Weyerhaeuser burn fossil fuels.

1-kilometer intervals is displayed as Figure 3. Although the city of Everett is situated on a plateau well above sea level and the Snohomish River Valley, Figure 3 indicates that much higher hills exist to the south of the Scott Paper mill and to the north on the Tulalip Reservation.

In the first round of modeling, each of the three models was run using sequential hourly meteorological data for 1982 using this 1-kilometer spaced grid of receptors. Calendar year 1982 was selected as a typical year for local meteorology. The output from each of the three models was examined to determine the geographic areas with the highest annual, 24-hour and 3-hour SO2 concentrations for further evaluation with all 5 years of meteorological data. Figure 3 also displays the receptors evaluated during this phase, the locations of the Scott ("S") and Weyerhaeuser ("W") mills, and the location of the Medical-Dental Building monitor ("M").

In the second round, a more tightly spaced group of receptors was selected for each model and for each area with peak concentrations. In addition, ten discrete receptors were added to account for local hospitals, schools and the PSAPCA monitoring station at the Medical-Dental Building. ISCST, COMPLEX-1 and SHORTZ were each run with this more refined group of receptors for five years of sequential hourly meteorological data, from 1982 through 1986. The highest annual, 24-hour, and 3-hour SO2 and highest annual and 24-hour particulate matter concentrations were noted for each year for each of the models.

In the final round of modeling, the days in which the highest 24-hour and 3-hour concentrations occurred were modeled to determine emission source contributions and the meteorological conditions which produced the peak concentrations.

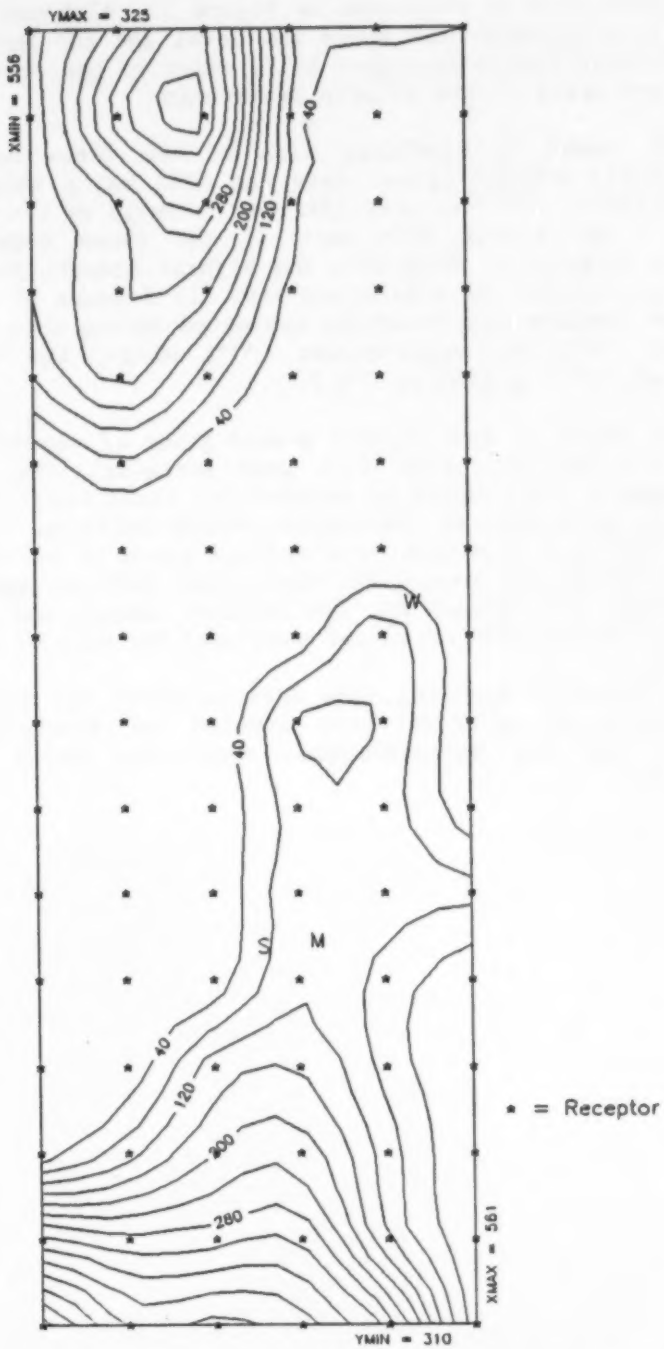


FIGURE 3: STUDY AREA GROUND ELEVATION (FEET ABOVE MSL)

RESULTS

In this section, the results of each of the modeling rounds is discussed, followed by a discussion of the implications of using maximum permitted emission rates, rather than actual emission rates. Next, a comparison is made between the model predictions and the measured concentrations in the Everett area. Finally, the meteorological conditions which produced the highest concentrations are identified for each of the three models.

Large Grid (1982)

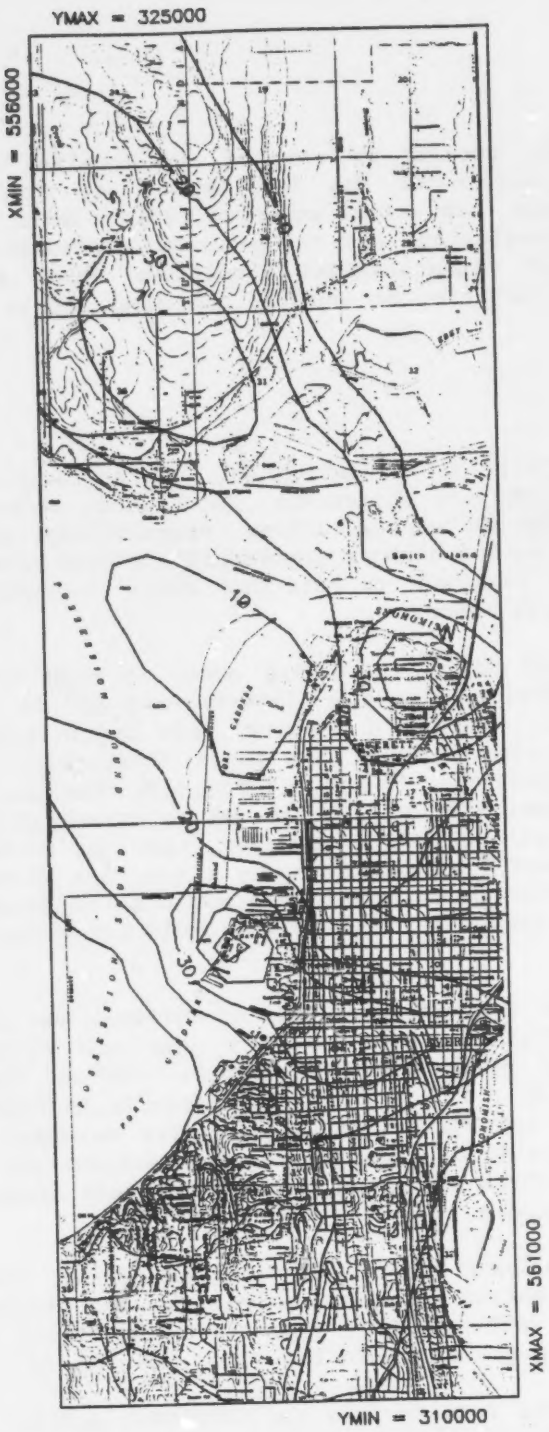
The results of the large grid modeling for 1982 are depicted in Figures 4-12. Figures 4-6 display the annual average, 2nd-highest 24-hour average and 2nd-highest 3-hour average SO2 concentrations, respectively, using ISCST. Figures 5 and 6 display the second highest concentrations that occurred during 1982 at each receptor; it is important to note that these concentrations did not occur at the same time for all locations.

Figures 4-6 show that ISCST calculates areas of high concentrations in the vicinity of Legion Park southwest of Weyerhaeuser and in the Rucker Hill area south of Scott Paper. It should be noted that Legion Park is about the same elevation as the shortest two of the three Weyerhaeuser stacks; the source contributions displayed later in Table 5 indicate that the high concentrations result from these short stacks. An area of relatively high SO2 concentration also appears just northwest of Scott Paper, near the south end of the jetty. Although the predominance of southeasterly winds (see Figure 1) would suggest that higher annual average concentrations would be expected to the northwest, it seems likely that only building downwash could bring the plume down so close to the sources.

To verify a suspicion that ISCST's building downwash was responsible for some of the high concentrations observed very near the Scott and Weyerhaeuser plants, ISCST was run again with 1982 data but without the building downwash employed. Figures A-1, A-2 and A-3 in the appendix indicate that the areas of higher concentration near Scott and Weyerhaeuser disappear when the downwash option is not employed (i.e., when building dimensions are not entered). The effect holds for all three averaging times but is more dramatic for the 24-hour and 3-hour averaging times.

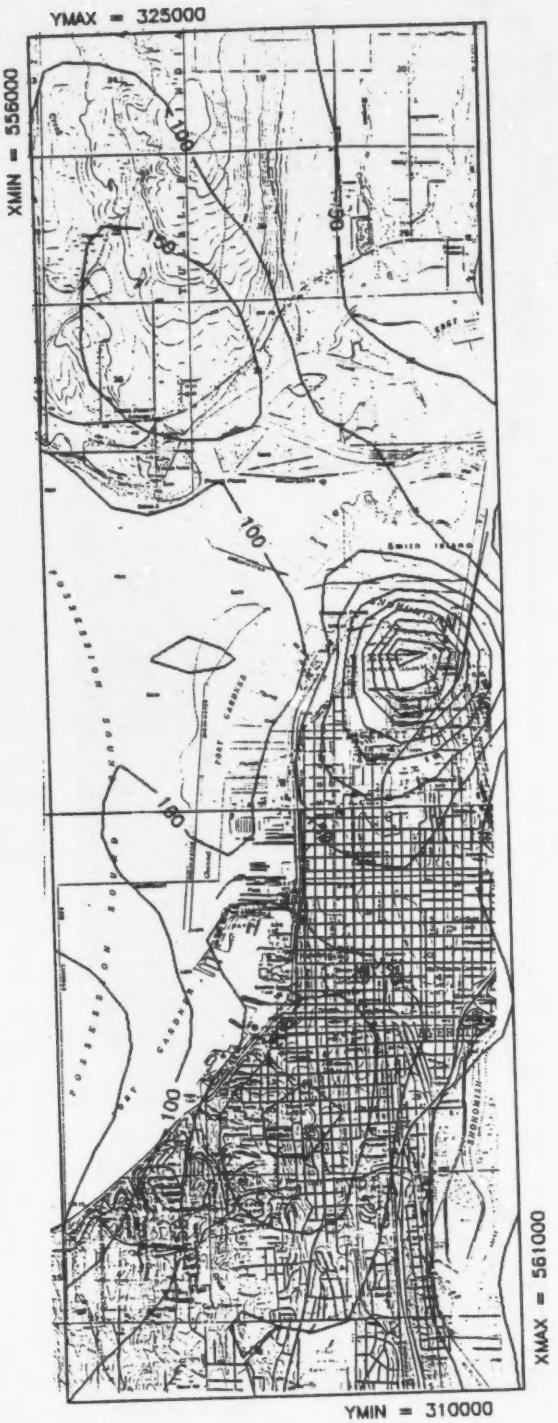
Downwash has little effect on concentrations on farther from the plants. The highest distant concentrations are observed at the higher terrain on the Tulalip reservation west of Marysville; slightly lower concentrations are calculated for the higher terrain to the south and east of Scott.

Figures 7-9 display the results from the COMPLEX-1 model. COMPLEX-1 does not produce the higher concentrations adjacent to the plants, probably because it does not consider building downwash. COMPLEX-1 calculates its highest concentrations just north of Priest Point on the Tulalip reservation. Higher



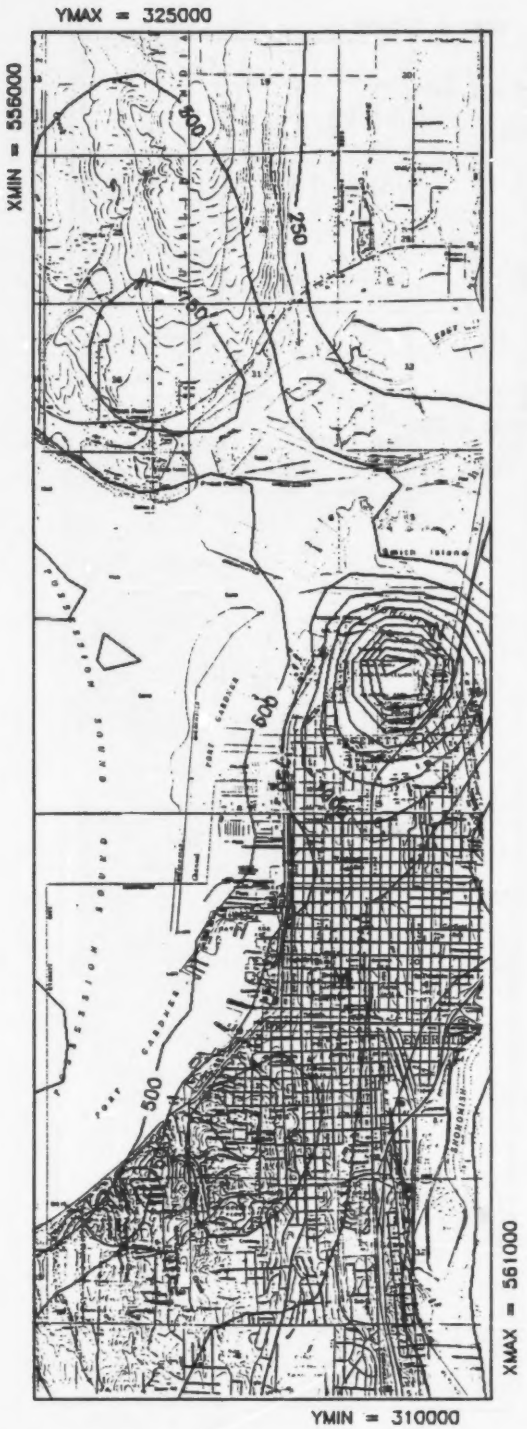
Reproduced from best available copy.

FIGURE 4: ANNUAL AVERAGE SO2 CONCENTRATIONS WITH ISCST (ug/m3)



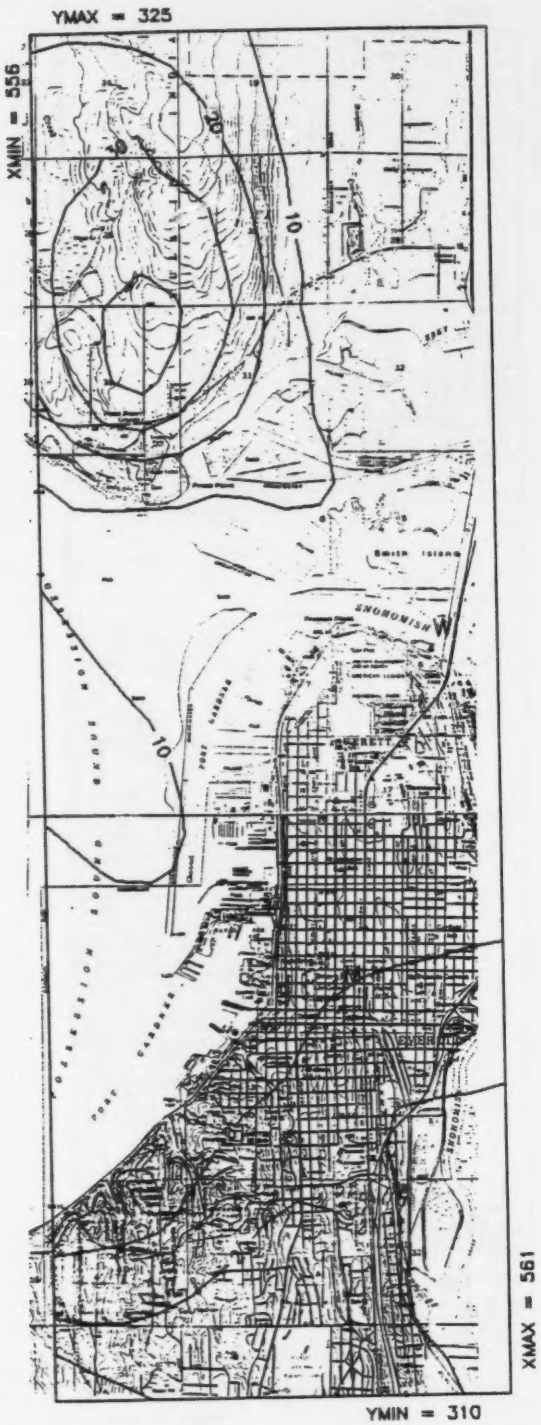
Reproduced from best available copy.

FIGURE 5: 2nd HIGHEST 24-HOUR AVERAGE SO2 CONCENTRATIONS WITH ISCST (ug/m3)



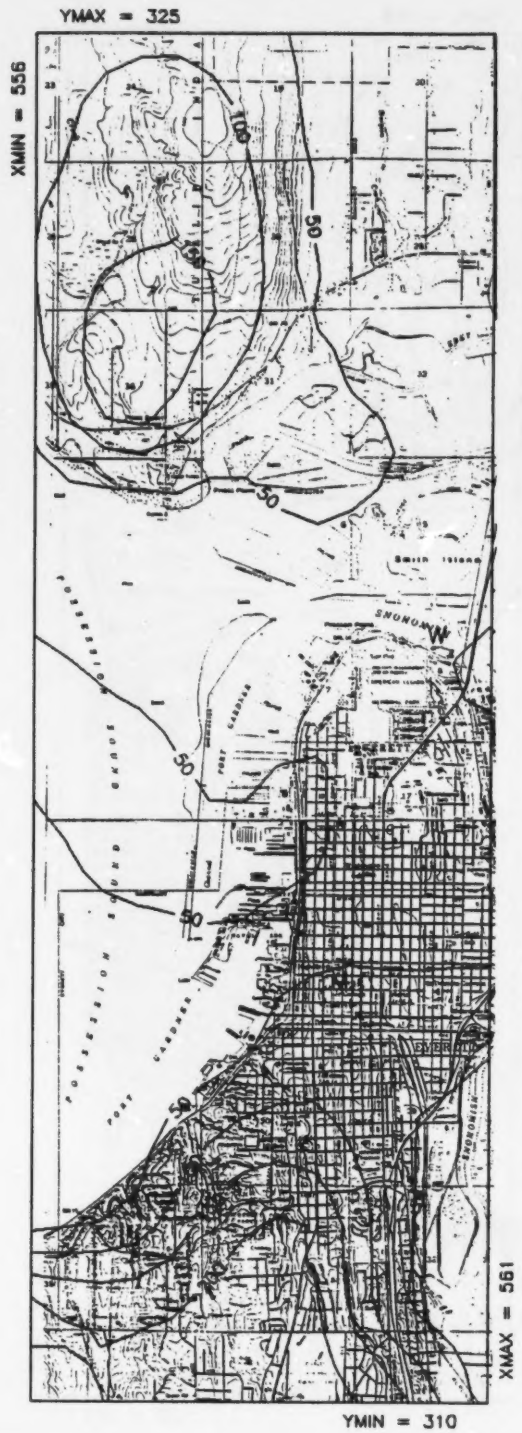
Reproduced from best available copy.

FIGURE 6: 2nd HIGH 3-HOUR AVERAGE SO2 CONCENTRATIONS WITH ISCST (ug/m3)



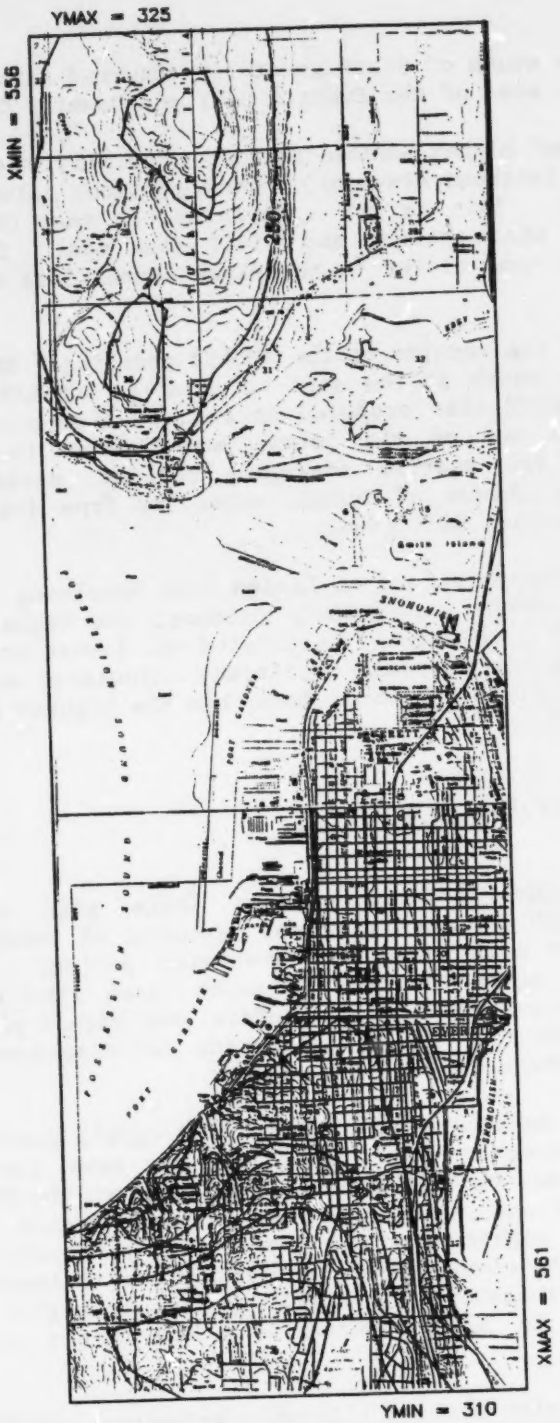
Reproduced from best available copy.

FIGURE 7: ANNUAL AVERAGE SO2 CONCENTRATIONS WITH COMPLEX-1 (ug/m3)



Reproduced from best available copy.

FIGURE 8: 2nd HIGHEST 24-HOUR AVERAGE SO2 CONCENTRATIONS WITH COMPLEX-1 (ug/m3)



Reproduced from best available copy.

FIGURE 9: 2nd HIGHEST 3-HOUR AVERAGE SO2 CONCENTRATIONS WITH COMPLEX-1 (ug/m3)

concentrations to the south of Scott generally occurred farther south than with ISCST, in the general area of the Everett Golf and Country Club.

Although the areas of higher concentrations generally occurred in the same places as with ISCST (without downwash), concentrations calculated by COMPLEX-1 were somewhat higher. This is not surprising, in that COMPLEX-1 recognizes terrain higher than stack height and ISCST does not. This means that an elevated receptor can come closer to the plume centerlines with COMPLEX-1 than with ISCST.

Figures 10-12 display the results of the SHORTZ modeling. SHORTZ produced peak concentrations to the north at the same location as COMPLEX-1 did, just north of Priest Point. SHORTZ also produced an area of high concentration west of Scott near the south end of the jetty, and another in Everett's central business district. For shorter averaging periods, maximum concentrations occurred south and southeast of Scott, extending from the central business district over to the Rucker Hill area.

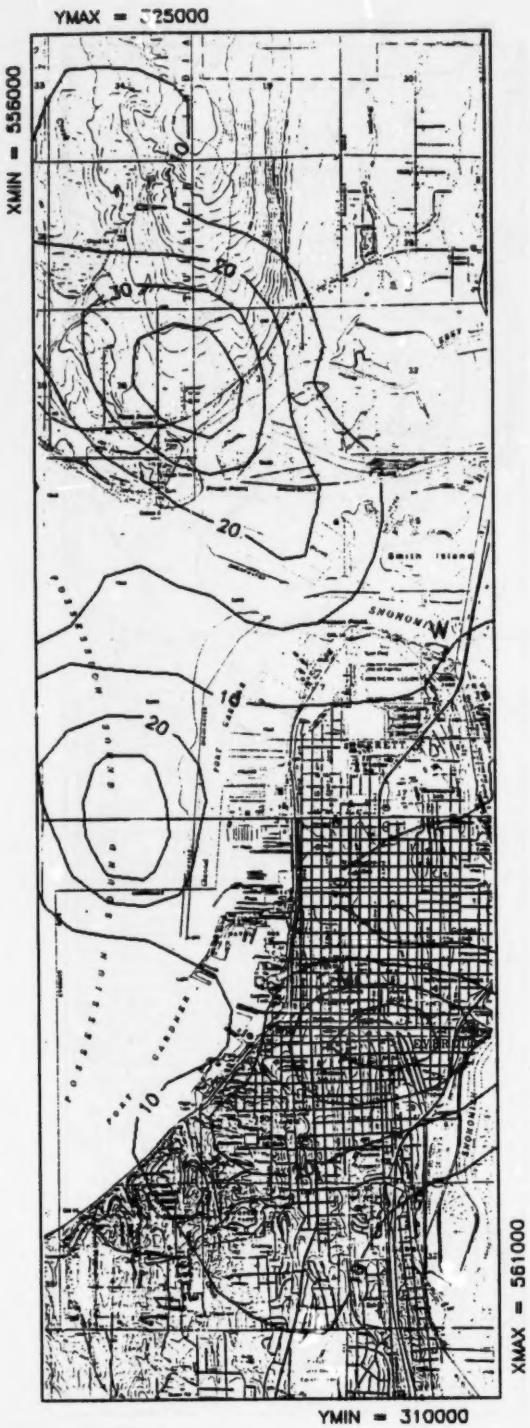
Except for the peak concentrations at Legion Park resulting from downwash from Weyerhaeuser stacks, SHORTZ consistently produced the highest concentrations. Without downwash, ISCST consistently calculated the lowest concentrations. All three models (ignoring the downwash condition) calculated the highest 24-hour and 3-hour SO2 concentrations south of Scott but the highest annual averages on the Tulalip reservation.

Discrete Receptor Grid (1982-1986)

Based on the isopleths produced with a large grid spacing and 1982 meteorological data, TRC produced a denser grouping of receptors at areas of high concentration for each model and averaging period. This new set of receptors was modeled using the same emission rates (the maximum allowable under state law) and stack parameters as before, but with 5 years of sequential hourly meteorological data. The receptor grids are displayed as Figures A-4, A-5 and A-6 in the appendix.

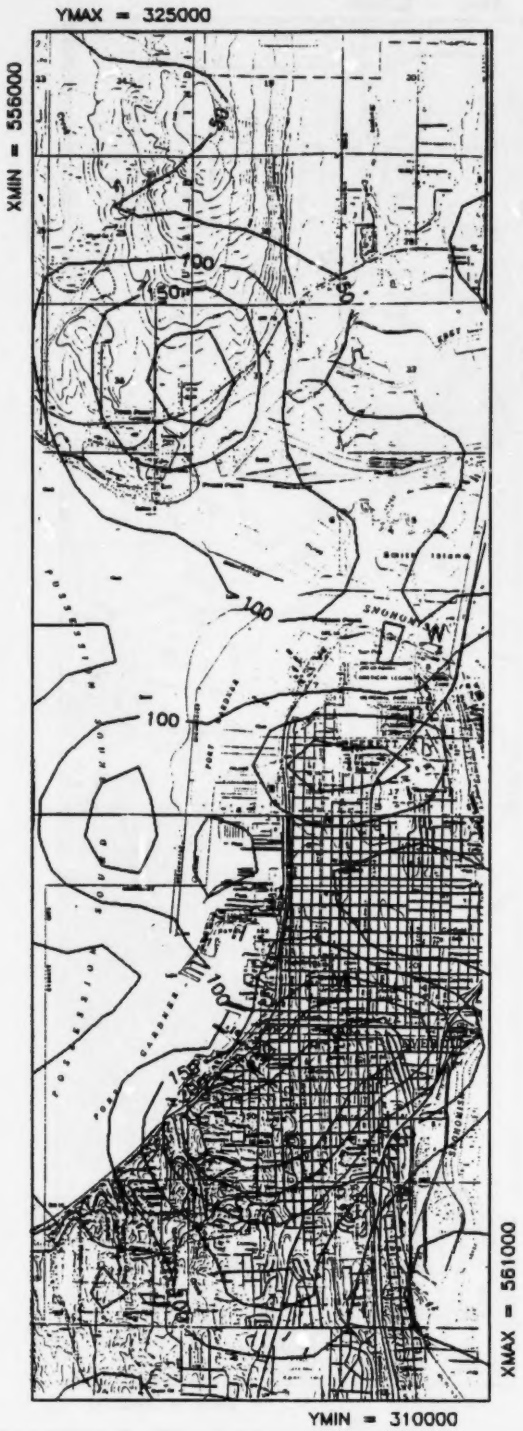
Table 2 summarizes the maximum concentrations (in ug/m^3) produced by the ISCST modeling. Maximum concentrations occur at the same location with both pollutants: annual average concentrations are highest at the PSAPCA monitor and shorter-term concentrations are highest at or near Legion Park. As noted before, Legion Park is higher than the lower two Weyerhaeuser stacks so ISCST automatically reduces the elevation at these receptors to these heights as each stack is evaluated. Similarly, the PSAPCA monitor is higher than all of the Scott sources, so it is also reduced to stack height as each stack is evaluated.

Table 2 indicates that with maximum allowable emissions, ISCST (with downwash) produces annual SO2 concentrations which are generally slightly higher than the ambient standard; predicted maximum concentrations for the 24-hour and 3-hour averaging periods are more than twice the ambient standards.



Reproduced from best available copy.

FIGURE 10: ANNUAL AVERAGE SO2 CONCENTRATIONS WITH SHORTZ (ug/m^3)



Reproduced from best available copy.

FIGURE 11: 2nd HIGHEST 24-HOUR AVERAGE SO2 CONCENTRATIONS WITH SHORTZ (ug/m^3)

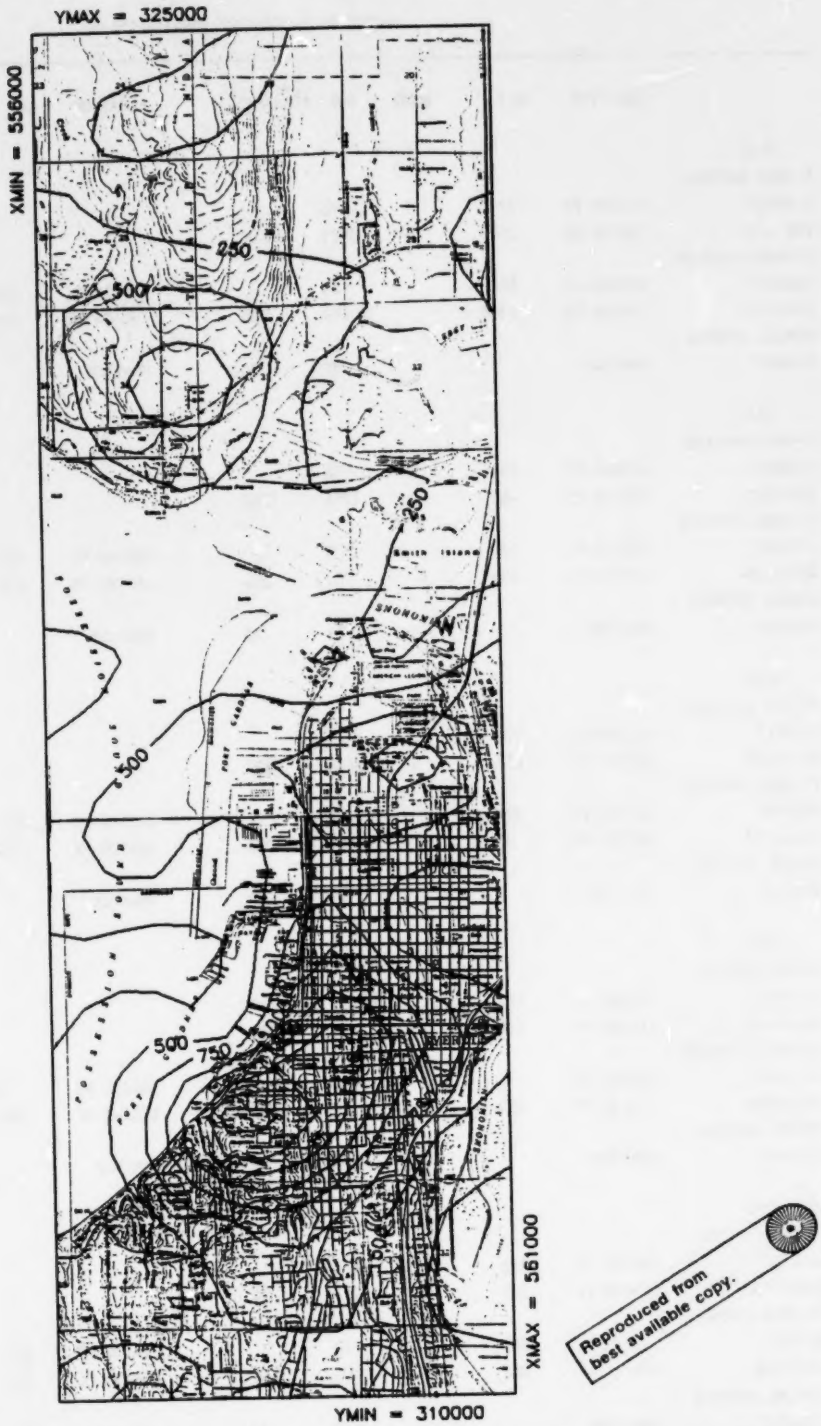


FIGURE 12: 2nd HIGH 3-HOUR AVERAGE SO2 CONCENTRATIONS WITH SHORTZ (ug/m^3)

TABLE 2: SUMMARY OF ISCST RESULTS

	LOCATION	DAY	HOUR	SO2	STANDARD	LOCATION	DAY	PM10	STANDARD
1982									
3-HOUR AVERAGE									
HIGHEST	LEGION PK	229	3	4976					
2nd-HIGH	LEGION PK	257	6	3925	1300				
24-HOUR AVERAGE									
HIGHEST	LEGION PK	260		916		LEGION PK	260	81	
2nd-HIGH	LEGION PK	286C		708	365	LEGION PK	286	62	150
ANNUAL AVERAGE									
HIGHEST	MONITOR			89	80	MONITOR		11	50
1983									
3-HOUR AVERAGE									
HIGHEST	LEGION PK	206	3	5516					
2nd-HIGH	LEGION PK	107	6	3796	1300				
24-HOUR AVERAGE									
HIGHEST	LEGION PK	107		775		LEGION PK	107	71	
2nd-HIGH	LEGION PK	206		753	365	LEGION PK	206	66	150
ANNUAL AVERAGE									
HIGHEST	MONITOR			84	80	MONITOR		10	50
1984									
3-HOUR AVERAGE									
HIGHEST	EO LEGION	164	3	4571					
2nd-HIGH	LEGION PK	213	3	3608	1300				
24-HOUR AVERAGE									
HIGHEST	LEGION PK	276C		750		LEGION PK	271	68	
2nd-HIGH	LEGION PK	33		681	365	LEGION PK	.33C	60	150
ANNUAL AVERAGE									
HIGHEST	MONITOR			79	80	MONITOR		9	50
1985									
3-HOUR AVERAGE									
HIGHEST	LEGION PK	240	3	4057					
2nd-HIGH	LEGION PK	204	3	3152	1300				
24-HOUR AVERAGE									
HIGHEST	LEGION PK	1C		689		LEGION PK	1C	61	
2nd-HIGH	LEGION PK	182		683	365	LEGION PK	182	60	150
ANNUAL AVERAGE									
HIGHEST	MONITOR			97	80	MONITOR		12	50
1986									
3-HOUR AVERAGE									
HIGHEST	LEGION PK	136	3	4325					
2nd-HIGH	LEGION PK	135	3	4251	1300				
24-HOUR AVERAGE									
HIGHEST	LEGION PK	343		877		LEGION PK	343	77	
2nd-HIGH	LEGION PK	285		705	365	LEGION PK	285	63	150
ANNUAL AVERAGE									
HIGHEST	MONITOR			89	80	MONITOR		11	50
FIVE-YEAR HIGH									
3-HOUR AVERAGE									
(1983) HIGHEST	LEGION PK	206	3	5516					
(1986) 2nd-HIGH	LEGION PK	135	3	4251	1300				
24-HOUR AVERAGE									
(1982) HIGHEST	LEGION PK	260		916		(1982)LEGION PK	260	81	
(1983) 2nd-HIGH	LEGION PK	206		753	365	(1983)LEGION PK	206	66	150
ANNUAL AVERAGE									
1985 HIGHEST	MONITOR			97	80	(1985)MONITOR		12	50

The maximum particulate concentrations produced by ISCST are all less than the PM-10 standards. Annual average concentrations are about 20 percent of the standard; 24-hour concentrations are about half the standard.

Table 3 summarizes the maximum concentrations from the COMPLEX-1 modeling. The maximum annual average SO2 and PM-10 concentrations occurred at the PSAPCA monitoring site. Shorter-term maximum SO2 concentrations generally occurred at Providence Hospital (south of Scott near Rucker Hill), but also occurred at the monitor for some 24-hour periods. The maximum 24-hour average PM-10 concentrations all occurred at the Providence Hospital receptor.

Annual SO2 concentrations calculated by COMPLEX-1 exceeded the ambient standard, and were generally slightly higher than with ISCST. Shorter-term SO2 concentrations were generally lower than those predicted with ISCST, but were all higher than the applicable standard.

PM-10 concentrations calculated by COMPLEX-1 were all below the standard. Annual average concentrations were almost identical to those estimated by ISCST, but 24-hour concentrations were generally slightly higher.

Table 4 summarizes the maximum concentrations from the SHORTZ modeling. As with ISCST and COMPLEX-1, SHORTZ calculates the highest annual concentrations at the PSAPCA monitor. All 3-hour and 24-hour maxima occur on Rucker Hill, south of Scott.

SHORTZ calculated lower annual average SO2 concentrations than ISCST and COMPLEX-1, with maximum concentrations less than the ambient standard. Shorter-term SO2 concentrations calculated by SHORTZ are higher than with COMPLEX-1, and comparable to ISCST, with concentrations two or more times the standard.

Calculated annual PM-10 concentrations are also lower than those calculated with the other models. SHORTZ calculated 24-hour PM-10 concentrations which were generally higher than the other models, but they were still well below the standard.

Maximum Short-term Episodes

The final round of modeling focused on the sources responsible for the peak concentrations calculated during the modeling of the discrete receptors for 5 years. Table 5 displays the concentration produced by each of the six sources at the location with the highest and second highest concentration of SO2 and PM-10.

A review of Table 5 indicates that the results of COMPLEX-1 and SHORTZ, which accept receptor heights higher than stack height, compare well qualitatively. Both models indicate much higher contributions from Scott than Weyerhaeuser, with Scott's recovery boiler and power boilers 6-10 dominating. Quantitatively, the models do not agree well. SHORTZ predicts much higher concentrations than COMPLEX-1, especially in the 3-hour SO2 calculations.

TABLE 3: SUMMARY OF COMPLEX-1 MODEL RESULTS

	LOCATION	DAY	HOUR	SO2	STANDARD	LOCATION	DAY	PM10	STANDARD
1982									
3-HOUR AVERAGE									
HIGHEST	PROV.HOSP	162	3	2603					
2nd-HIGH	PROV.HOSP	326	3	2383	1300				
24-HOUR AVERAGE									
HIGHEST	PROV.HOSP	326		693		PROV.HOSP	326	86	
2nd-HIGH	PROV.HOSP	231		523	365	PROV.HOSP	231	74	150
ANNUAL AVERAGE									
HIGHEST	MONITOR			93	80	MONITOR		10	50
1983									
3-HOUR AVERAGE									
HIGHEST	PROV.HOSP	166	24	2660					
2nd-HIGH	PROV.HOSP	203	24	2386	1300				
24-HOUR AVERAGE									
HIGHEST	MONITOR	33		571		PROV.HOSP	166	75	
2nd-HIGH	MONITOR	236		470	365	PROV.HOSP	203	63	150
ANNUAL AVERAGE									
HIGHEST	MONITOR			87	80	MONITOR		9	50
1984									
3-HOUR AVERAGE									
HIGHEST	PROV.HOSP	154	3	2921					
2nd-HIGH	PROV.HOSP	243	24	2786	1300				
24-HOUR AVERAGE									
HIGHEST	PROV.HOSP	212		605		PROV.HOSP	212	84	
2nd-HIGH	PROV.HOSP	154		532	365	PROV.HOSP	164	73	150
ANNUAL AVERAGE									
HIGHEST	MONITOR			82	80	MONITOR		9	50
1985									
3-HOUR AVERAGE									
HIGHEST	PROV.HOSP	239	24	2615					
2nd-HIGH	PROV.HOSP	177	3	2110	1300				
24-HOUR AVERAGE									
HIGHEST	PROV.HOSP	177		673		PROV.HOSP	177	93	
2nd-HIGH	MONITOR	168		411	365	PROV.HOSP	118	51	150
ANNUAL AVERAGE									
HIGHEST	MONITOR			100	80	MONITOR		11	50
1986									
3-HOUR AVERAGE									
HIGHEST	PROV.HOSP	173	3	2430					
2nd-HIGH	PROV.HOSP	228	6	2062	1300				
24-HOUR AVERAGE									
HIGHEST	PROV.HOSP	343		532		PROV.HOSP	343	61	
2nd-HIGH	PROV.HOSP	313		437	365	PROV.HOSP	278	58	150
ANNUAL AVERAGE									
HIGHEST	MONITOR			98	80	MONITOR		11	50
FIVE-YEAR HIGH									
3-HOUR AVERAGE									
(1984) HIGHEST	PROV.HOSP	154	3	2921					
(1984) 2nd-HIGH	PROV.HOSP	243	24	2786	1300				
24-HOUR AVERAGE									
(1982) HIGHEST	PROV.HOSP	326		693		(1985)MONITOR	177	93	
(1984) 2nd-HIGH	PROV.HOSP	154		532	365	(1982)MONITOR	231	74	150
ANNUAL AVERAGE									
(1985) HIGHEST	MONITOR			100.3	80	(1986)MONITOR		11	50

TABLE 4: SUMMARY OF SHORTZ RESULTS

	LOCATION	DAY	HOUR	SO2 STANDARD		LOCATION	DAY	PM-10 STANDARD	
1982									
3-HOUR AVERAGE									
HIGHEST	RUCKER HILL	192	3	3355					
2nd-HIGH	RUCKER HILL	312	24	3247	1300				
24-HOUR AVERAGE									
HIGHEST	RUCKER HILL	326	24	750		RUCKER HILL	326	79	
2nd-HIGH	RUCKER HILL	343	24	634	365	RUCKER HILL	318	73	150
ANNUAL AVERAGE									
HIGHEST	MONITOR	365	24	60	80	MONITOR	365	7	50
1983									
3-HOUR AVERAGE									
HIGHEST	RUCKER HILL	39	3	4523					
2nd-HIGH	RUCKER HILL	157	3	4046	1300				
24-HOUR AVERAGE									
HIGHEST	RUCKER HILL	232	24	763		RUCKER HILL	232	91	
2nd-HIGH	RUCKER HILL	232	24	743	365	RUCKER HILL	117	81	150
ANNUAL AVERAGE									
HIGHEST	MONITOR	365	24	53	80	MONITOR	365	6	50
1984									
3-HOUR AVERAGE									
HIGHEST	RUCKER HILL	124	24	5069					
2nd-HIGH	RUCKER HILL	124	24	5043	1300				
24-HOUR AVERAGE									
HIGHEST	RUCKER HILL	212	24	892		RUCKER HILL	212	100	
2nd-HIGH	RUCKER HILL	124	24	814	365	RUCKER HILL	124	89	150
ANNUAL AVERAGE									
HIGHEST	MONITOR	366	24	52	80	MONITOR	366	6	50
1985									
3-HOUR AVERAGE									
HIGHEST	RUCKER HILL	68	6	4800					
2nd-HIGH	RUCKER HILL	121	3	3970	1300				
24-HOUR AVERAGE									
HIGHEST	RUCKER HILL	6	24	753		RUCKER HILL	6	82	
2nd-HIGH	RUCKER HILL	68	24	733	365	RUCKER HILL	68	75	150
ANNUAL AVERAGE									
HIGHEST	MONITOR	365	24	55	80	MONITOR	365	8	50
1986									
3-HOUR AVERAGE									
HIGHEST	RUCKER HILL	273	24	3828					
2nd-HIGH	RUCKER HILL	253	21	3809	1300				
24-HOUR AVERAGE									
HIGHEST	RUCKER HILL	211	24	796		RUCKER HILL	211	89	
2nd-HIGH	RUCKER HILL	343	24	671	365	RUCKER HILL	194	60	150
ANNUAL AVERAGE									
HIGHEST	MONITOR	365	24	61	80	MONITOR	365	7	50
FIVE-YEAR HIGH									
3-HOUR AVERAGE									
(1984) HIGHEST	RUCKER HILL	124	24	5069					
(1984) 2nd HIGH	RUCKER HILL	124	24	5043	1300				
24-HOUR AVERAGE									
(1984) HIGHEST	RUCKER HILL	212	24	892		(1984) RUCKER HILL		100	
(1984) 2nd HIGH	RUCKER HILL	124	24	814	365	(1984) RUCKER HILL		89	150
ANNUAL AVERAGE									
(1986) HIGHEST	MONITOR	365	24	61	80	(1985) MONITOR		8	50

TABLE 5: SUMMARY OF SOURCE CONTRIBUTIONS TO PEAK EPISODES WITH MAXIMUM EMISSIONS

POLLUTANT / AVERAGING PERIOD	-- WEYERHAEUSER -- REC. BLR.	P.B. # 1	P.B. # 2	---- SCOTT ------- REC. BLR.	P.B. 1-5	P.B. 6-10	ALL SOURCES	AMBIENT STANDARD
ISCST								
SO2: 3-hr high	0	2632	2884	0	0	0	5516	
3-hr 2nd	0	2087	2163	0	0	0	4251	1300
24-hr high	0	435	482	0	0	0	916	
24-hr 2nd	0	363	391	0	0	0	753	365
PM-10: 24-hr high	0	38	42	0	0	0	81	
24-hr 2nd	0	32	34	0	0	0	66	150
COMPLEX-1								
SO2: 3-hr high	0	0	0	1371	230	1320	2921	
3-hr 2nd	0	0	0	1588	262	936	2785	1300
24-hr high	1	4	6	284	67	331	693	
24-hr 2nd	3	8	9	310	24	169	523	365
PM-10: 24-hr high	0	0	1	66	7	18	93	
24-hr 2nd	0	1	1	55	2	15	74	150
SHORTZ								
SO2: 3-hr high	0	0	0	2061	1090	1919	5069	
3-hr 2nd	0	0	0	1955	764	2315	5034	1300
24-hr high	19	11	20	355	129	358	892	
24-hr 2nd	0	0	0	312	127	375	814	365
PM-10: 24-hr high	3	1	2	63	11	21	100	
24-hr 2nd	0	0	0	55	11	23	89	150

The ISCST results are completely different, reflecting the fact that the maximum concentrations were predicted at Legion Park rather than downtown Everett. ISCST calculated maximum concentrations from Weyerhaeuser's two power boiler stacks. These stacks are each about 118 feet tall, considerably shorter than the 280 foot recovery boiler stack.

Tables 6, 7A, 7B and 7C identify the meteorological conditions which produced the peak concentrations displayed in Table 5. Table 6 indicates that the peak 3-hour SO_2 concentrations all occurred during stable periods with 1-2 meter per second winds from the north or northeast. Table 7A, 7B and 7C indicate that the weather on the days producing the highest 24-hour average SO_2 concentrations also included at least 11 hours of stable conditions; during the stable periods, winds were generally from 1-3 meters per second and had a strong northerly component. As indicated by the windrose displayed in Figure 1, northerly and northeasterly winds are not common wind directions. It is not surprising, then, that the highest annual average average concentrations are observed in a different location than the short-term peaks.

Estimated Concentrations Based on Actual Emissions

As indicated in Table 1, actual emissions are much less than permitted emissions. For example, Scott's actual SO2 emissions from its recovery boiler and power boilers 6-10 were only about 45 percent and 15 percent, respectively, of allowable emissions. Therefore, annual average and probably shorter-term concentrations are likely to be significantly lower than the concentrations displayed in Table 5.

If only one source were involved, the concentrations calculated with maximum allowable emissions could simply be scaled back to determine the concentrations resulting from actual emissions. In this study, however, six sources were involved, and the ratio of permitted to actual emissions was different for each source and each pollutant. Because each source produces its maximum impact under specific meteorological conditions, it is not completely accurate to reduce each source contribution by the ratio of actual to permitted emissions, and sum the results. Nonetheless, it does provide a rough estimate of the reduction in ambient concentrations which would be expected with actual rather than permitted emissions.

Table 8 presents the concentrations which TRC estimated by reducing the source contributions displayed in Table 5 by the ratio of actual to permitted emissions. Table 8 indicates that concentrations estimated by this method are all lower than the ambient standard, although the 3-hour average SO_2 concentrations predicted by SHORTZ are close to the standard. Annual average concentrations for actual conditions are not identified because the models do not provide annual average source contributions.

TABLE 6: METEOROLOGICAL CONDITIONS PRODUCING THE PEAK 3-HOUR SO_2 CONCENTRATIONS

ISCST

HOUR	FLOW VECTOR (DEGREES)	RANDOM FLOW VECTOR (DEGREES)	WIND SPEED (MPS)	MIXING HEIGHT (METERS)	TEMP. (DEG. K)	INPUT STABILITY CATEGORY	ADJUSTED STABILITY CATEGORY
1	220.0	215.0	1.70	1248.0	287.0	6	6
2	220.0	216.0	1.92	1222.0	288.0	6	6
3	210.0	211.0	2.28	1196.0	288.0	6	6

COMPLEX-1

HOUR	FLOW VECTOR (DEGREES)	RANDOM FLOW VECTOR (DEGREES)	WIND SPEED (MPS)	MIXING HEIGHT (METERS)	TEMP. (DEG. K)	INPUT STABILITY CATEGORY	ADJUSTED STABILITY CATEGORY
1	180.0	182.0	2.01	1472.5	284.0	6	6
2	190.0	185.0	1.03	1474.5	283.0	6	6
3	170.0	171.0	1.00	1476.5	283.0	6	6

SHORTZ

HOUR	FLOW VECTOR (DEGREES)	RANDOM FLOW VECTOR (DEGREES)	WIND SPEED (MPS)	MIXING HEIGHT (METERS)	TEMP. (DEG. K)	INPUT STABILITY CATEGORY	ADJUSTED[1] STABILITY CATEGORY
22	180.0	183.0	1.43	2187.8	281.0	6	6
23	180.0	176.0	1.07	2152.4	281.0	6	6
24	180.0	179.0	1.74	2117.0	280.0	6	6

1 Although F-stability was observed, all F-stabilities were converted to E-stabilities in the SHORTZ model runs.

TABLE 7A: METEOROLOGICAL CONDITIONS PRODUCING PEAK 24-HOUR SO_2 CONCENTRATIONS

ISCST

HOUR	FLOW VECTOR (DEGREES)	RANDOM FLOW VECTOR (DEGREES)	WIND SPEED (MPS)	MIXING HEIGHT (METERS)	TEMP. (DEG. K)	INPUT STABILITY CATEGORY	ADJUSTED STABILITY CATEGORY
1	220.0	219.0	1.00	1126.1	288.0	6	6
2	240.0	238.0	1.56	1094.9	286.0	6	6
3	210.0	208.0	2.68	1063.6	287.0	6	6
4	220.0	218.0	1.65	1032.4	286.0	6	6
5	220.0	219.0	1.48	1001.1	285.0	6	6
6	250.0	246.0	1.00	11.8	285.0	6	6
7	220.0	225.0	1.00	100.3	287.0	5	5
8	190.0	190.0	1.00	188.8	288.0	4	4
9	180.0	182.0	1.00	277.4	290.0	3	3
10	90.0	91.0	2.28	365.9	292.0	2	2
11	100.0	99.0	3.49	454.4	294.0	2	2
12	100.0	98.0	3.76	542.9	296.0	2	2
13	100.0	100.0	3.35	631.5	298.0	2	2
14	90.0	89.0	3.84	720.0	299.0	2	2
15	100.0	99.0	4.38	720.0	299.0	3	3
16	100.0	95.0	3.84	720.0	299.0	3	3
17	100.0	95.0	3.17	720.0	299.0	4	4
18	90.0	93.0	3.31	720.0	296.0	4	4
19	90.0	91.0	3.13	726.7	293.0	5	5
20	90.0	93.0	3.53	735.5	293.0	6	6
21	100.0	102.0	3.04	744.4	291.0	6	6
22	100.0	97.0	1.25	753.2	290.0	6	6
23	220.0	221.0	1.00	762.1	291.0	6	6
24	280.0	279.0	1.56	771.0	290.0	6	6

TABLE 7B: METEOROLOGICAL CONDITIONS PRODUCING PEAK 24-HOUR SO_2 CONCENTRATIONS

COMPLEX-1

HOUR	FLOW VECTOR (DEGREES)	RANDOM FLOW VECTOR (DEGREES)	WIND SPEED (MPS)	MIXING HEIGHT (METERS)	TEMP. (DEG. K)	INPUT STABILITY CATEGORY	ADJUSTED STABILITY CATEGORY
1	170.0	173.0	1.83	776.4	273.0	6	6
2	170.0	165.0	1.03	777.1	273.0	6	6
3	180.0	179.0	1.25	777.9	273.0	6	6
4	130.0	131.0	1.16	778.6	272.0	6	6
5	180.0	176.0	1.83	779.3	272.0	6	6
6	170.0	169.0	2.10	780.1	272.0	6	6
7	220.0	221.0	1.70	780.8	272.0	6	6
8	160.0	156.0	1.65	62.4	272.0	6	6
9	170.0	169.0	1.56	183.0	273.0	5	5
10	140.0	144.0	1.16	303.6	274.0	4	4
11	140.0	140.0	1.48	424.2	276.0	3	3
12	160.0	155.0	2.32	544.8	278.0	2	2
13	120.0	118.0	1.70	665.4	279.0	2	2
14	170.0	173.0	1.74	786.0	281.0	2	2
15	160.0	159.0	2.73	786.0	280.0	3	3
16	130.0	131.0	4.16	786.0	279.0	4	4
17	160.0	164.0	2.41	775.3	277.0	5	5
18	190.0	188.0	1.97	758.0	275.0	6	6
19	170.0	171.0	1.65	740.7	275.0	6	6
20	150.0	150.0	2.28	723.4	274.0	6	6
21	150.0	148.0	1.83	706.1	274.0	6	6
22	130.0	129.0	1.61	688.8	275.0	6	6
23	160.0	157.0	2.06	671.5	276.0	6	6
24	200.0	203.0	2.37	654.2	274.0	6	6

TABLE 7C: METEOROLOGICAL CONDITIONS PRODUCING PEAK 24-HOUR SO_2 CONCENTRATIONS

SHORTZ

HOUR	FLOW VECTOR (DEGREES)	RANDOM FLOW VECTOR (DEGREES)	WIND SPEED (MPS)	MIXING HEIGHT (METERS)	TEMP. (DEG. K)	INPUT STABILITY CATEGORY	ADJUSTED[1] STABILITY CATEGORY
1	200.0	195.0	3.13	1375.8	290.0	6	6
2	180.0	178.0	2.46	1367.6	289.0	6	6
3	180.0	177.0	2.19	1359.5	288.0	6	6
4	180.0	183.0	2.15	1351.4	288.0	6	6
5	170.0	173.0	1.79	22.8	288.0	6	6
6	200.0	202.0	1.70	161.4	288.0	5	5
7	160.0	159.0	2.06	300.0	290.0	4	4
8	90.0	94.0	2.50	438.6	291.0	3	3
9	100.0	97.0	3.53	577.1	293.0	2	2
10	100.0	96.0	3.80	715.7	295.0	2	2
11	90.0	92.0	3.67	854.3	296.0	2	2
12	100.0	96.0	4.38	992.9	298.0	2	2
13	100.0	96.0	4.65	1131.4	300.0	2	2
14	100.0	101.0	5.72	1270.0	301.0	3	3
15	100.0	101.0	5.90	1270.0	301.0	3	3
16	100.0	101.0	5.81	1270.0	300.0	3	3
17	90.0	92.0	5.10	1270.0	300.0	3	3
18	100.0	100.0	5.59	1270.0	300.0	3	3
19	110.0	109.0	7.24	1270.0	298.0	4	4
20	110.0	109.0	6.84	1270.2	296.0	5	5
21	110.0	105.0	5.05	1270.8	294.0	5	5
22	120.0	116.0	3.13	1271.4	294.0	6	6
23	180.0	179.0	1.97	1272.0	293.0	6	6
24	210.0	213.0	1.97	1272.6	291.0	6	6

1 Although F-stability was observed, all F-stabilities were converted to E-stabilities in the SHORTZ model runs.

TABLE 8:ESTIMATE OF SOURCE CONTRIBUTIONS TO PEAK EPISODES WITH ACTUAL EMISSIONS

POLLUTANT / AVERAGING PERIOD	-- WEYERHAEUSER -- REC. BLR.	P.B. # 1	P.B. # 2	---- SCOTT ------- REC. BLR.	P.B. 1-5	P.B. 6-10	ALL SOURCES	AMBIENT STANDARD
ACTUAL/ALLOWABLE[1]								
SO_2	.29	.31	.06	.45	.002	.13		
PM-10	.76	.25	.06	.17	1.01	.11		
ISCST								
SO2: 3-hr high	0	816	894	0	0	0	989	
3-hr 2nd	0	647	130	0	0	0	777	1300
24-hr high	0	135	29	0	0	0	164	
24-hr 2nd	0	113	23	0	0	0	136	365
PM-10:24-hr high	0	10	3	0	0	0	12	
24-hr 2nd	0	8	2	0	0	0	10	150
COMPLEX-1								
SO2: 3-hr high	0	0	0	617	0	172	789	
3-hr 2nd	0	0	0	715	1	122	837	1300
24-hr high	0	1	0	128	0	43	173	
24-hr 2nd	1	2	1	140	0	22	165	365
PM-10:24-hr high	0	0	0	11	7	2	20	
24-hr 2nd	0	0	0	9	2	2	13	150
SHORTZ								
SO2: 3-hr high	0	0	0	927	2	249	1179	
3-hr 2nd	0	0	0	880	2	301	1183	1300
24-hr high	6	3	1	160	0	47	217	
24-hr 2nd	0	0	0	140	0	49	189	365
PM-10:24-hr high	2	0	0	11	11	2	27	
24-hr 2nd	0	0	0	9	11	3	23	150

1 This is fraction of the allowable emission rate which each source operated at in 1985 or 1986.

Table 9 presents the highest and second-highest concentrations recorded at the PSAPCA monitoring site at the Medical Dental Building in downtown Everett in 1984, 1985 and 1986. Table 9 also displays the highest concentration calculated by the three models for each averaging time for both permitted and actual emission rates. It should be noted that all three models indicate that the maximum annual average concentrations resulting from maximum permitted emissions would occur at the monitor, but shorter term maxima occur at other locations. The modeling indicates that the existing monitor location is well positioned to measure the maximum annual average concentrations from Scott and Weyerhaeuser, but that monitors near Providence Hospital and near Legion Park may be better for monitoring short term concentrations.

The modeling indicates that Scott and Weyerhaeuser emissions account for most of the SO2 measured at the Medical-Dental Building. But because the predicted PM-10 concentrations from the two plants are significantly lower than the measured values, it is likely that other sources are important contributors to local PM-10.

In summary, the modeling indicates that SO2 standards would be exceeded with maximum allowable SO2 emissions, but that PM-10 concentrations would be well below ambient standards.. The concentrations estimated by reducing each source contribution in proportion to its actual emissions during 1985/1986 are below ambient standards.

TABLE 9: SUMMARY OF MEDICAL DENTAL BUILDING MONITORING DATA

	1984	1985	1986	MAXIMUM MODEL RESULTS WITH MAXIMUM EMISSIONS	MAXIMUM MODEL RESULTS WITH ACTUAL EMISSIONS	AMBIENT STANDARD
SULFUR DIOXIDE (PPM)						
Annual Average	.010	.011	.011	.038 (C)		
Highest 24-hour	.059	.038	.043	.350 (I)	0.08 (S)	
2nd-High 24-hour	.050	.034	.038	.310 (S)	0.07 (S)	0.14
Highest 3-hour	.163	.200	.227	2.11 (I)	0.45 (S)	
2nd-High 3-hour	.147	.080	.077	1.92 (S)	0.45 (S)	0.50
PARTICULATE MATTER (ug/m^3)						
	PM-10	PM-10	PM-10			
Annual Average	36	36	29	12 (I)		
Highest 24-hour	174	80	73	100 (S)	27 (S)	
2nd-High 24-hour	165	77	68	89 (S)	23 (S)	150

SOURCE: 1984-1986 Air Quality Data Summaries, PSAPCA.

KEY: (I) ISCST, (C) COMPLEX-1, (S) SHORTZ

REFERENCES

Bjorklund, J.R., and J.F. Bowers, 1982. User's Instructions for the SHORTZ and LONGZ Computer Programs, Volumes I and II. EPA Publication No. EPA 903/9-82-004a and b, U.S. Environmental Protection Agency, Region III, Philadelphia, PA.

Bowers, J.F., W.R. Hargraves and A.J. Anderson, 1982. Recommendations on a SHORTZ/LONGZ SO_2 Air Quality Model Methodology for the Tacoma Tideflats Area. Prepared for U.S. Environmental Protection Agency Region 10, Publication No. EPA-910/9-82-090.

Burt, E.W., 1977. Valley Model User's Guide. EPA Publication No. EPA-450/2-77-018. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. PB 274054).

Environmental Protection Agency, 1986a. Guideline on Air Quality Models (Revised). Publication No. EPA-450/2-78-027R.

Environmental Protection Agency, 1986b. Industrial Source Complex (ISC) Dispersion Model User's Guide, Second Edition, Volumes I and 2. Publication Nos. EPA-450/4-86-005a, and -005b. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Holzworth, George C., 1972. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States. Environmental Protection Agency Office of Air Programs Publication No. AP-101.

Turner, D.B., and J.H. Novak, 1978. User's Guide for RAM. Publication No. EPA-600/8-78-016 Vols a, and b. U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS PB 294791 and PB 294792). Also see the RAM Addendum distributed by U.S. Environmental Protection Agency as part of UNAMAP Version 6 Documentation.

Washington Department of Ecology, 1987. Letter from Stuart A. Clark, Manager of Air Programs to Robert Wilson, Regional 10 Meteorologist, U.S. Environmental Protection Agency.

APPENDIX

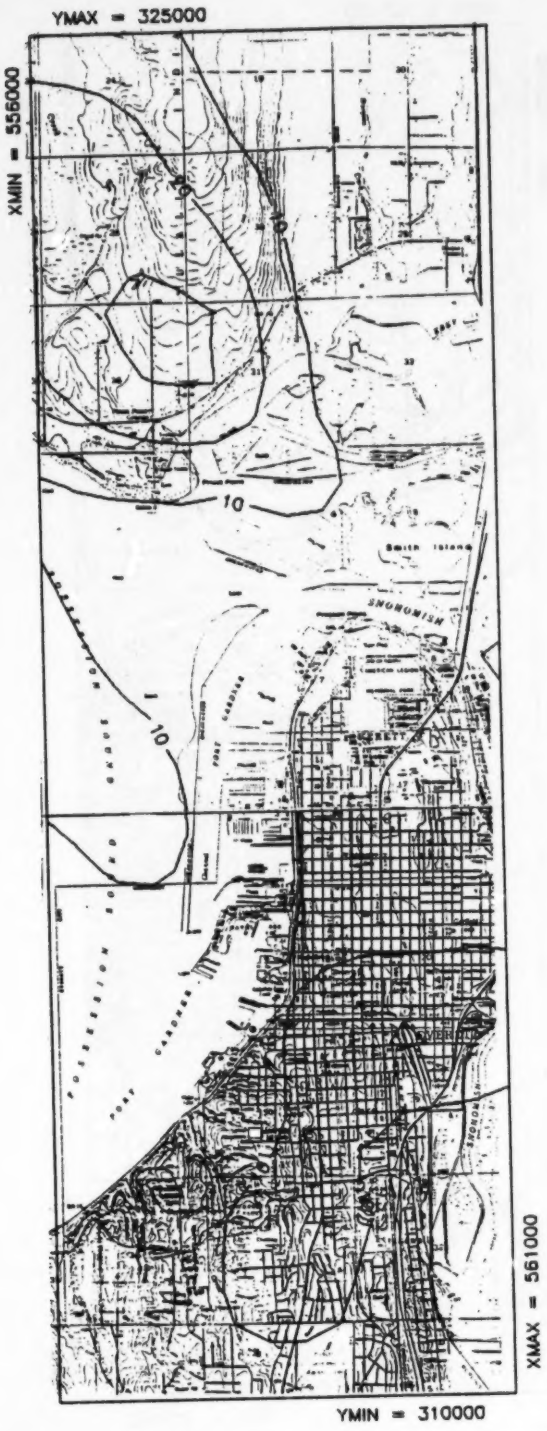
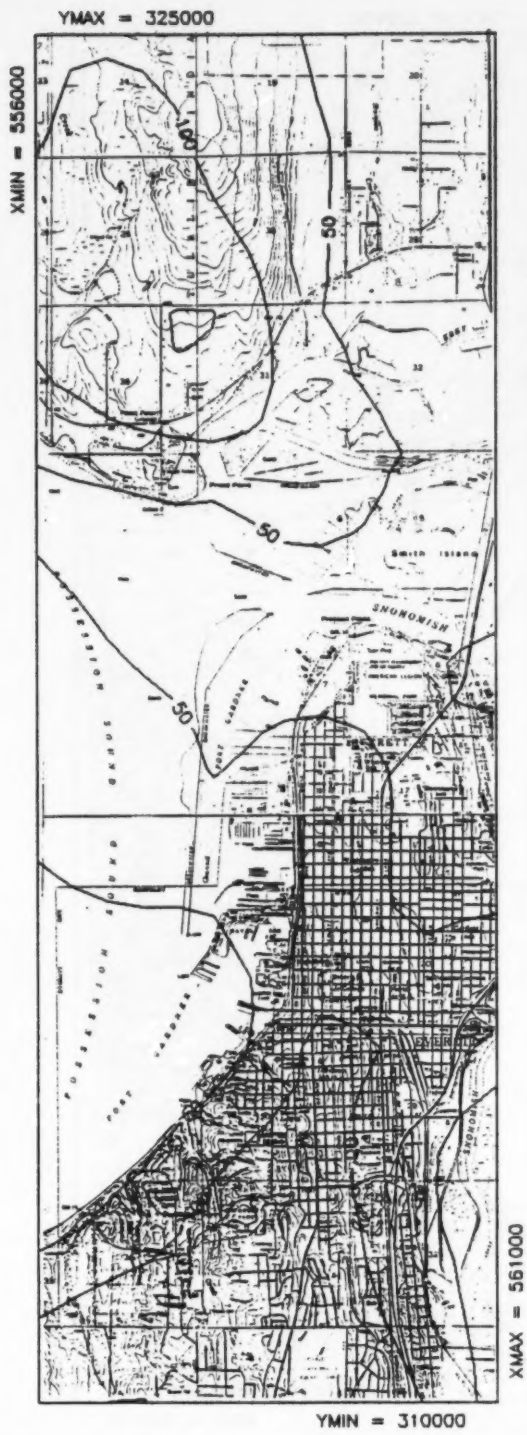


FIGURE A-1: ANNUAL AVERAGE SO2 CONCENTRATIONS WITH ISCST WITHOUT DOWNWASH

Reproduced from
best available copy.



Reproduced from best available copy.

FIGURE A-2: 2ND-HIGHEST 24-HOUR SO2 CONCENTRATIONS WITH ISCST WITHOUT DOWNWASH

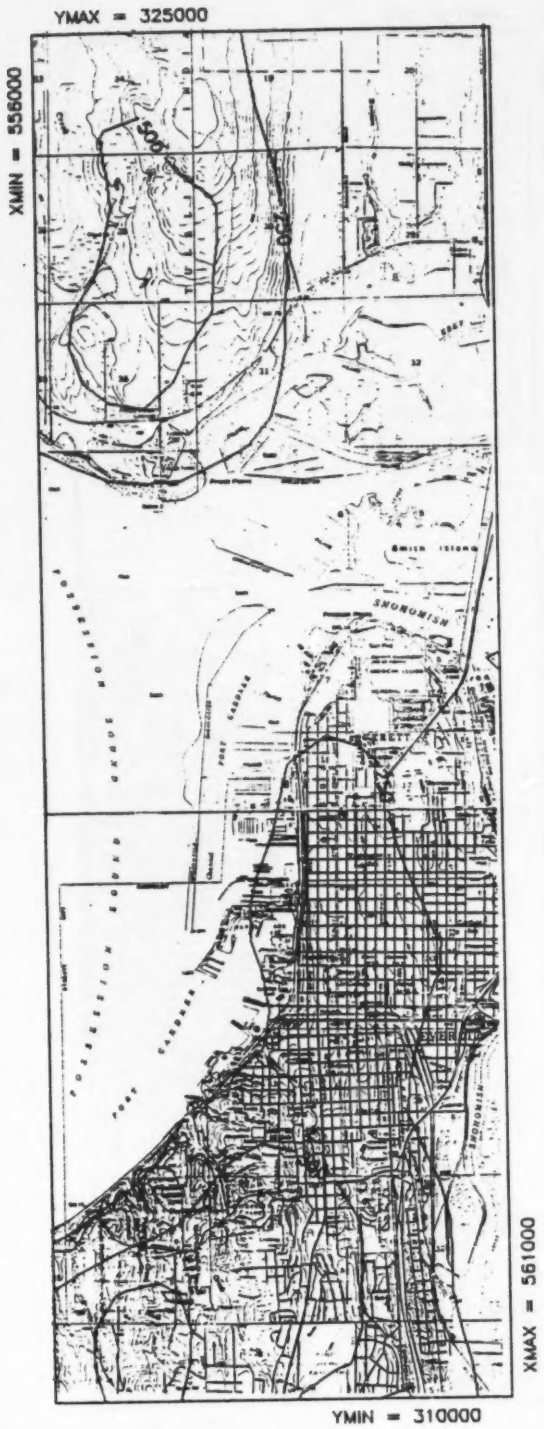
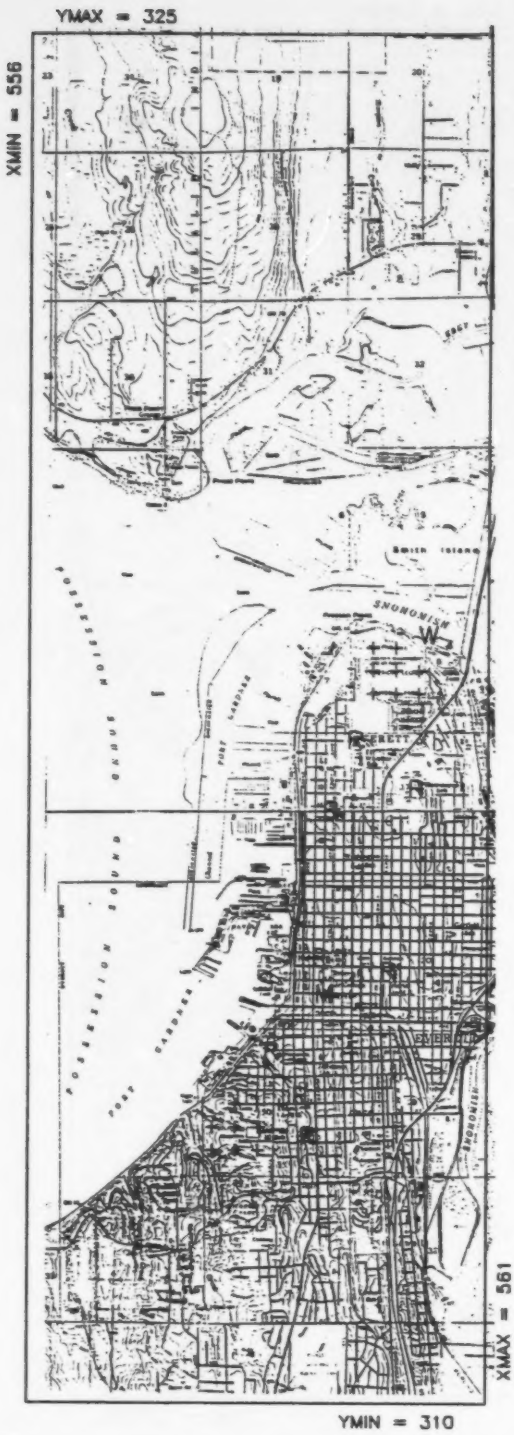


FIGURE A-3: 2ND HIGHEST 3-HOUR SO2 CONCENTRATIONS WITH ISCST WITHOUT DOWNWASH

Reproduced from
best available copy.



Reproduced from best available copy.

FIGURE A-4: FINE RECEPTOR GRID FOR ISCST MODELING

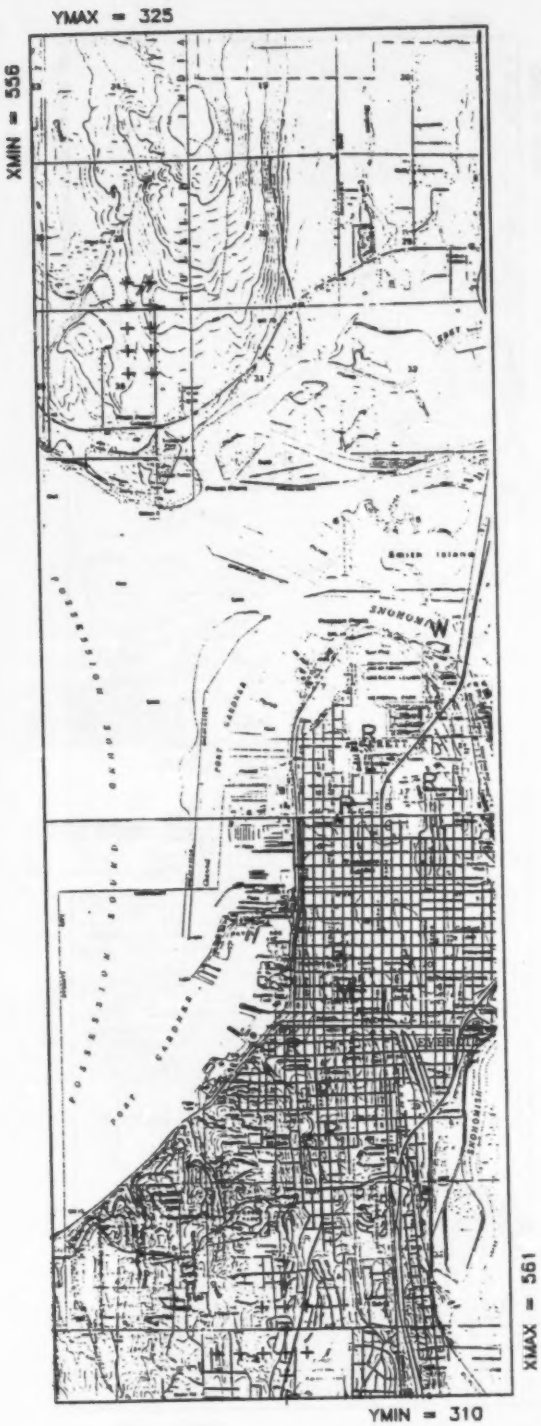
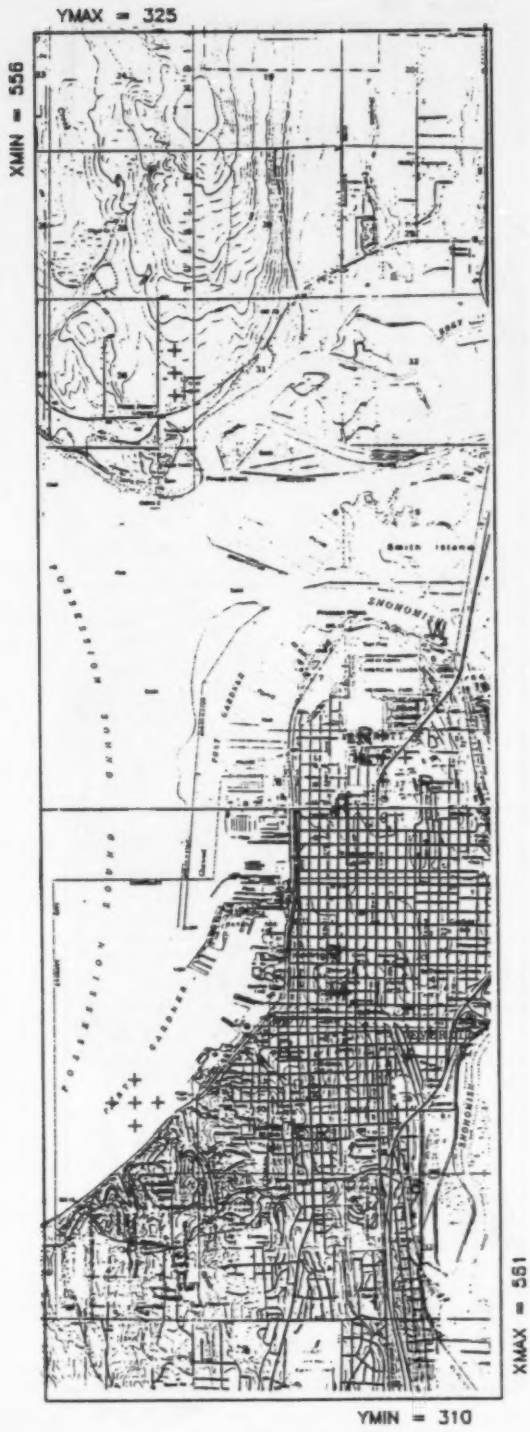


FIGURE A-5: FINE RECEPTOR GRID FOR COMPLEX1 MODELING

Reproduced from best available copy.

B409
10



Reproduced from best available copy.

FIGURE A-6: FINE RECEPTOR GRID FOR SHORTZ MODELING